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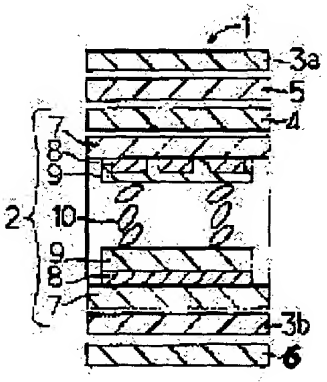
(54) REFLECTIVE-TYPE LIQUID CRYSTAL; DISPLAY DEVICE

(57)Abstract:
PROBLEM TO BE SOLVED: To provide an ECB (birefringence control) reflective-type color STN (super-twisted nematic) liquid crystal display device by which a problem that a display color is considerably changed by angles of observation is solved.
SOLUTION: A liquid crystal display device 1 consists of a liquid crystal display element 2, a polarizing plate 3a arranged on the observer side of the liquid crystal display element 2, a polarizing plate 3b arranged on the side opposite to the observer side of the liquid crystal display element 2, a phase difference plate 4 arranged between the liquid crystal display element 2 and the polarizing plate 3a, a light diffusion plate 5 arranged between the polarizing plate 3a and the phase difference plate 4, and a reflection plate 6 arranged on the outside of the polarizing plate 3b. A transparent electrode 8 and an oriented film 9 are formed on surfaces facing each other of a pair of glass substrates 7 forming the liquid crystal display element 2. Liquid crystal 10 is interposed between glass substrates 7. Thus, the ECB reflective-type color STN liquid crystal display device is constituted.



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* NOTICES *

CLAIMS

[Claim(s)]
[Claim 1] The reflected type LCD characterized by having the optical diffusion plate which diffuses light in the specific orientation between the polarizing plate by the side of an observer, and the aforementioned liquid-crystal-display element in the reflected type LCD to which an ECB method reflex type color STN liquid-crystal-display element comes to intervene between the polarizing plates of a couple.
[Claim 2] The reflected type LCD according to claim 1 characterized by having the phase contrast plate which improves the angle-of-visibility property of the orientation which is not diffused with the aforementioned optical diffusion plate between the polarizing plate by the side of an observer, and the aforementioned liquid-crystal-display element.
[Claim 3] It is the reflected type LCD according to claim 1 or 2 which the aforementioned optical diffusion plate carries out the laminating of the film of two sheets which has the field in which a refractive index is mutually different, and is constituted, and the aforementioned field is prepared in parallel with the orientation in which only the predetermined angle inclined in the aforementioned specific orientation to the orientation of a normal of a film, and is characterized by to set up the aforementioned angle of each film so that it may become the opposite orientation mutually considering the orientation of a normal as a center
[Claim 4] The aforementioned phase contrast plate is a reflected type LCD according to claim 2 or 3 to which the angle of the diffusion orientation of light and the lagging axis of the aforementioned phase contrast plate which the refractive indexes nx, ny, and nz of the orientation of 3 dimension have the relation of nx>nz>ny, and diffused with the aforementioned optical diffusion plate to make is characterized by 55 degrees or more being 75 degrees or less.
[Claim 5] The reflected type LCD according to claim 4 to which the coefficient Nz which shows the rate of the ********** value change to elevation angle change of the aforementioned phase contrast plate expressed with Nz=(nx-nz)/(nx-ny) is characterized by or more 0.2 being 0.4 or less when wavelength lambda is 633nm.

[Translation done.]

* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to the ECB method reflex type color STN (super twisted nematic) LCD which performs a color display especially about a reflected type LCD using the birefringence effect.
[0002]
[Description of the Prior Art] Although the reflected type monochrome STN LCD is adopted as the display of a carried type information device in consideration of portability, for the reason on check-by-looking ******, the development of the reflected type electrochromatic display display in which the color display of two or more colors is possible is performed. In order to realize a color display, without using a light filter especially, the development of an ECB (birefringence control) method reflex type color STN LCD is performed briskly.
[0003] In the principle of this ECB method reflex type color STN LCD, if a gradation voltage is impressed to a pixel, the orientation of a liquid crystal molecule will change according to the impressed gradation voltage, product ddeltan of cell thick d of a liquid-crystal-display element and refractive-index anisotropy deltan of liquid crystal will change in connection with this, and, as a result, coloring according to change of ddeltan will come out according to the birefringence effect of liquid crystal.
[0004] In STN type LCD used from the former, if it is possible to turn on and turn off light, using the light filter, color-izing is possible and ddeltan is set as 1000nm or less. However, in the LCD of ECB method, in order to carry out a multicolor display by change of ddeltan, without using a light filter, it is necessary to set ddeltan as a big value, and ddeltan is set as 1000nm or more.
[0005] Thus, since the birefringence nature of liquid crystal changes with the incident angles of light a lot by the LCD of ECB method by having set up ddeltan in big value of 1000nm or more, there is a trouble of changing with the angles at which a foreground color observes a LCD a lot (elevation angle change of a foreground color).
[0006] In order to solve this trouble, using for the LCD of ECB method the biaxial nature phase contrast plate with which the refractive index of the orientation of 3 dimension has the relation of nx>nz>ny is proposed as indicated by JP,8-15691,A.
[0007] By this technique, although the birefringence nature of liquid crystal changes with the incident angles of light, since the phase contrast with the case where light penetrates liquid crystal the case where it penetrates perpendicularly, and aslant, by the relation of the refractive index of the thing hardly changed even if the incident angle of light changes, and a biaxial nature phase contrast plate is compensated with a biaxial nature phase contrast plate, as for the birefringence nature of a biaxial nature phase contrast plate, elevation angle change of a foreground color is suppressed.
[0008]
[Problem(s) to be Solved by the Invention] However, even if it is the case where the technique currently indicated by JP,8-15691,A is used, since the LCD of ECB method has large ddeltan, a gap of the slight observation orientation also changes ddeltan and satisfaction of elevation angle change of a foreground color is impossible.
[0009] this invention is made in view of the above conventional troubles, and aims at offering the ECB method reflex type color STN LCD which has improved that a foreground color changes with the angles to observe a lot.
[0010]
[Means for Solving the Problem] In order to attain the purpose mentioned above, the reflected type LCD of this invention according to claim 1 is characterized by having the optical diffusion plate which diffuses light in the specific orientation between the polarizing plate by the side of an observer, and the aforementioned liquid-crystal-display element in the reflected type LCD to which an ECB method reflex type color STN liquid-crystal-display element comes to intervene between the polarizing plates of a couple.
[0011] The reflected type LCD according to claim 2 is characterized by having the phase contrast plate which improves the angle-of-visibility property of the orientation which is not diffused with the aforementioned optical diffusion plate between the polarizing plate by the side of an observer, and the aforementioned liquid-crystal-display element in the reflected type LCD according to claim 1.
[0012] A reflected type LCD according to claim 3 is set to a reflected type LCD according to claim 1 or 2. the aforementioned optical diffusion plate A refractive index carries out the laminating of the film of two sheets which has a mutually different field, and is constituted. the aforementioned field It is prepared in parallel with the orientation in which only the predetermined angle inclined in the aforementioned specific orientation to the orientation of a normal of a film, and is characterized by setting up the aforementioned angle of each film so that it may become the opposite orientation mutually considering the orientation of a normal as a center.
[0013] The angle of the diffusion orientation of light and the lagging axis of the aforementioned phase contrast plate which, as for the aforementioned phase contrast plate, the refractive indexes nx, ny, and nz of the orientation of 3 dimension have the relation of nx>nz>ny in a reflected type LCD according to claim 2 or 3, and the reflected type LCD according to claim 4 diffused with the aforementioned optical diffusion plate to make is characterized by 55 degrees or more being 75 degrees or less.

[0014] The coefficient Nz a reflected type LCD according to claim 5 indicates the rate of the ********** value change to elevation angle change of the aforementioned phase contrast plate expressed with Nz=(nx-nz)/(nx-ny) to be in a reflected type LCD according to claim 4 is characterized by or more 0.2 being 0.4 or less, when wavelength lambda is 633nm.
[0015] Elevation angle change of a foreground color can be improved, without reducing transverse-plane brightness by having the optical diffusion plate which diffuses light in the specific orientation between the polarizing plate by the side of an observer, and a liquid-crystal-display element according to the reflected type LCD of this invention. This is because the difference of the property produced with the wavelength of light by each hue is not further emphasized by the diffusion effect by the optical diffusion plate like the LCD using a light filter in order not to use a light filter in the case of an ECB method reflex type color STN LCD.
[0016] Moreover, elevation angle change of a foreground color is improvable [in all orientation] with an optical diffusion plate with a sufficient balance by having the phase contrast plate which improves the angle-of-visibility property of the orientation not to diffuse between the polarizing plate by the side of an observer, and a liquid-crystal-display element.
[0017] An optical diffusion plate carries out the laminating of the film of two sheets which has the field in which a refractive index is mutually different, and is constituted. furthermore, the aforementioned field It is prepared in parallel with the orientation in which only the predetermined angle inclined in the specific orientation to the orientation of a normal of a film. the aforementioned angle of each film Without being spread, the outgoing radiation of the light which carried out incidence of the orientation of a normal along the orientation of a normal of an optical diffusion plate by being set up so that it may become the opposite orientation mutually as a center is carried out as it is, and it secures transverse-plane brightness. And when the light which carried out incidence in the orientation which inclined to the orientation of a normal makes the inclination orientation in agreement with the specific orientation, it is spread in the specific orientation and elevation angle change of a foreground color is improved.
[0018] Furthermore, a phase contrast plate can improve elevation angle change of a foreground color with a sufficient balance in all orientation, when the angle of the diffusion orientation of light and the lagging axis of a phase contrast plate which the refractive indexes nx, ny, and nz of the orientation of 3 dimension have the relation of nx>nz>ny, and diffused with the optical diffusion plate to make is 55 degrees or more 75 degrees or less. Since a 3-dimensional phase contrast plate can control freely ********** change in the elevation angle of the orientation of a lagging axis (the degree is expressed with a coefficient Nz), elevation angle change of a foreground color is improvable to the conventional phase contrast plate (two-dimensional). And by setting the angle which the lagging axis of the optical diffusion orientation of an optical diffusion plate and a 3-dimensional phase contrast plate makes as 55 degrees or more 75 degrees or less, the improvement orientation of elevation angle change of the foreground color by the optical diffusion plate and the improvement orientation of elevation angle change of the foreground color by the 3-dimensional phase contrast plate can be balanced, and elevation angle change of a foreground color can be improved with a sufficient balance in all orientation.
[0019] Furthermore, the coefficient Nz which shows the rate of the ********** value change to elevation angle change of a phase contrast plate expressed with Nz=(nx-nz)/(nx-ny) can improve elevation angle change of a foreground color with a sufficient balance in all orientation by [or more 0.2] being 0.4 or less, when wavelength lambda is 633nm.
[0020]
[Embodiments of the Invention] The gestalt and the example of a comparison of operation of this invention are explained using the drawing 1 or the drawing 14 .
[0021] (Gestalt of operation) The gestalt of operation of this invention is explained using view 1 or the drawing 8 . The cross section showing the LCD concerning this invention in drawing 1 , explanatory drawing showing the phase contrast plate concerning this invention in drawing 2 , The cross section showing the optical diffusion plate concerning this invention in drawing 3 , explanatory drawing showing the arrangement conditions of each part material that drawing 4 constitutes the LCD concerning this invention, Explanatory drawing showing color difference change of the 6:00 to 12:00 orientation of [when drawing 5 changes a coefficient Nz to 0.1-0.5], Explanatory drawing showing color difference change of the 3:00 to 9:00 orientation of [when drawing 6 changes a coefficient Nz to 0.1-0.5], Explanatory drawing showing color difference change of the 6:00 to 12:00 orientation of [when drawing 7 changes the angle of the orientation of a lagging axis and the optical diffusion orientation to make to 50 degrees - 80 degrees], Drawing 8 is explanatory drawing showing color difference change of the 3:00 to 9:00 orientation of [at the time of changing the angle of the orientation of a lagging axis, and the optical diffusion orientation to make to 50 degrees - 80 degrees].
[0022] As shown in drawing 1 , LCD 1 concerning this invention The liquid-crystal-display element 2 and polarizing plate 3a arranged at the observer side of the liquid-crystal-display element 2, It consists of an optical diffusion plate 5 arranged between the phase contrast plate 4 arranged between polarizing plate 3b arranged at the non-observer side of the liquid-crystal-display element 2, and the liquid-crystal-display element 2 and polarizing plate 3a, and polarizing plate 3a and the phase contrast plate 4, and a reflecting plate 6 arranged on the outside of polarizing plate 3b.
[0023] In the front face in which the transparent electrode 8 which consists of ITO (indium stannic-acid ghost), respectively was formed in the front face on which the glass substrate 7 of the couple which has the translucency which constitutes the liquid-crystal-display element 2 counters, and the transparent electrode 8 of a glass substrate 7 was formed, the orientation layer 9 which consists of a polyimide resin etc. is mostly formed in the whole surface, respectively.
[0024] Orientation processing is performed by rubbing so that the orientation layer 9 may take the torsion structure where the liquid crystal molecule of the liquid crystal 10 which intervenes between glass substrates 7 is 250 degrees. The mixed liquid crystal material which added cholesteric nonanoate severalpercent is used for the nematic liquid crystal which has a positive dielectric constant anisotropy as liquid crystal 10 as chiral matter for regulating the orientation of torsion. deltan of a mixed liquid crystal material is 0.24, and cell ** of the liquid-crystal-display element 2 is set as 7.5 micrometers.
[0025] A 3-dimensional phase contrast plate is used for the phase contrast plate 4 at polarizing plates 3a and 3b using 45% of simple substance permeability, and the thing of 99.9% of degree of polarization.

[0026] When refractive indexes differ in the orientation of 3 dimension, respectively, the principal indices of refraction of three orientation is set to nx, ny, and nz, the refractive index of 3-dimensional phase contrast plate surface inboard is set to nx and ny (nx> ny) and the refractive index of the thickness orientation of a 3-dimensional phase contrast plate is set to nz, the 3-dimensional phase contrast plate is set up so that it may be set to nx>nz>ny.

[0027] If the rate of change of ********** corresponding to change of the elevation angle of a 3-dimensional phase contrast plate is specified as coefficient Nz=(nx-nz)/(nx-ny) using the refractive index of 3-dimensional one, when wavelength lambda is 633nm, Nz=0.2-0.4 are desirable and use the thing of Nz=0.3 in the gestalt of this operation. Moreover, the quality of the material consists of a polycarbonate, and the ********** value uses the 2000nm thing.

[0028] The phase contrast plate 4 used with the gestalt of this operation is the configuration which arranged the lagging axis 12 and carried out the laminating of the with Nz=0.3 and a ********** value [of 400nm] phase contrast film 11 of five sheets, as shown in drawing 2 .

[0029] As shown in drawing 3 , what carried out the laminating of the films 14a and 14b which arranged in by turns two kinds of fields 13a and 13b in which a refractive index is mutually different about 0.04 so that it might have fixed angle theta (for 30 degrees - 50 degrees is desirable, and uses a 45-degree thing in the gestalt of this operation although theta can be set up arbitrarily), for example, Sumitomo Chemical ****** tea etc., is used for the optical diffusion plate 5.

[0030] Although the outgoing radiation of the light 15 which carried out incidence to the optical diffusion plate 5 perpendicularly is carried out as it is, the light 16 which carried out incidence in parallel with angle theta can be diffused by the Bragg diffraction, and can improve elevation angle change of a foreground color. However, on the other hand, the light 16 in which films 14a and 14b carried out incidence in parallel with angle theta constitutionally is diffused only in **, and, on the other hand, can improve only elevation angle change of the foreground color of **.

[0031] For this reason, in the gestalt of this operation, the laminating of the films 14a and 14b is carried out so that angle theta may become the opposite orientation mutually considering the orientation of a normal as a center, for example, elevation angle change of the foreground color of the 2-way of 3:00 -9:00 orientation is improved.

[0032] The optical diffusion plate 5 used with the gestalt of this operation does not have phase contrast, and it arranges it between polarizing plate 3a and the phase contrast plate 4 in order to protect the optical diffusion plate 5.

[0033] Next, the arrangement conditions of each part material which constitutes LCD 1 are explained. As shown in drawing 4 , as arrow head A shows, 35 degrees (rubbing shaft) of the liquid crystal molecular orientation shafts of one orientation layer 9 lean to the clockwise rotation from 9:00 orientation. As arrow head B shows, 55 degrees of the liquid crystal molecular orientation shaft orientations of the orientation layer 9 of another side lean to the clockwise rotation from 12:00 orientation. Therefore, angle of torsion of a liquid crystal molecule is set as 250 degrees.

[0034] The optical diffusion orientation of the optical diffusion plate 5 is a 2-way of 3:00 -9:00 orientation, as arrow head C shows. As arrow head D shows, 70 degrees of the absorption shaft orientations of polarizing plate 3a lean to the clockwise rotation from 12:00 orientation. As arrow head E shows, 5 degrees of the absorption shaft orientations of polarizing plate 3b lean to the clockwise rotation from 6:00 orientation. Moreover, as arrow head F shows, the 30 degrees of the lagging-axis 12 orientation of the phase contrast plate 4 lean to the clockwise rotation from 6:00 orientation.

[0035] In order to improve elevation angle change of a foreground color with a sufficient balance in all orientation, it is desirable to set the angle of the lagging-axis 12 orientation of the phase contrast plate 4 and the optical diffusion orientation of the optical diffusion plate 5 to make, i.e., the angle of arrow head C and arrow head F to make, as 55 degrees - 75 degrees. In the gestalt of this operation, the angle of arrow head C and arrow head F to make is set as 60 degrees.

[0036] Here, the coefficient Nz of the phase contrast plate 4 explains the ground nil why 0.2-0.4 are desirable.

[0037]

[Equation 1]

$$\Delta E^*ab$$

[0038] The above-mentioned formula is JIS. Z It is shown that color difference change becomes large and an angle-of-visibility property becomes bad so that this value becomes large, since the color difference is expressed according to 8729 and the color right above is made into the zero.

[0039] As shown in drawing 5 , when changing a coefficient Nz to 0.1-0.5, at the time of Nz=0.1 and Nz=0.5, the color difference becomes large and, as for color difference change of 6:00 to 12:00 orientation, the angle-of-visibility property is bad.

[0040] Moreover, as shown in drawing 6 , when changing a coefficient Nz to 0.1-0.5, at the time of Nz=0.1 and Nz=0.5, the color difference becomes large and, as for color difference change of 3:00 to 9:00 orientation, the angle-of-visibility property is bad.

[0041] Therefore, when coefficients Nz are 0.2-0.4, elevation angle change of a foreground color can be improved with a sufficient balance in all the orientation.

[0042] Furthermore, the ground with desirable setting the angle of the lagging-axis 12 orientation of the phase contrast plate 4 and the optical diffusion orientation of the optical diffusion plate 5 to make as 55 degrees - 75 degrees is explained.

[0043] As shown in drawing 7 , when changing the angle of lagging-axis 12 orientation and the optical diffusion orientation to make to 50 degrees - 80 degrees, color difference change of 6:00 to 12:00 orientation is not so big a difference.

[0044] However, as shown in drawing 8 , when changing the angle of lagging-axis 12 orientation and the optical diffusion orientation to make to 50 degrees - 80 degrees, when the angles of lagging-axis 12 orientation and the optical diffusion orientation to make are 50 degrees and 80 degrees, the color difference becomes large and, as for color difference change of 3:00 to 9:00 orientation, the angle-of-visibility property is bad.

[0045] Therefore, when the angle of lagging-axis 12 orientation and the optical diffusion orientation to make is set as 55 degrees - 75 degrees, elevation angle change of a foreground color can be improved with a sufficient balance in all the orientation.

[0046] (Example of a comparison) The example of a comparison is explained using view 9 and the drawing 10 . The cross

section and the drawing 10 showing the LCD of the former [drawing / 9] are explanatory drawing showing the arrangement conditions of each part material which constitutes the conventional LCD.

[0047] As shown in drawing 9 , conventional LCD 51 consists of a phase contrast plate 52 arranged between the liquid-crystal-display element 2, polarizing plate 3a arranged at the observer side of the liquid-crystal-display element 2, polarizing plate 3b arranged at the non-observer side of the liquid-crystal-display element 2, and the liquid-crystal-display element 2 and polarizing plate 3a, and a reflecting plate 6 arranged on the outside of polarizing plate 3b.

[0048] The liquid-crystal-display element 2 is the same as that of the gestalt of operation of this invention, and the orientation layer 9 which consists of a polyimide resin etc. is mostly formed in the whole surface, respectively in the front face in which the transparent electrode 8 which consists of ITO, respectively was formed in the front face on which the glass substrate 7 of the couple which has a translucency counters, and the transparent electrode 8 of a glass substrate 7 was formed.

[0049] Orientation processing is performed by rubbing so that the orientation layer 9 may take the torsion structure where the liquid crystal molecule of the liquid crystal 10 which intervenes between glass substrates 7 is 250 degrees. The mixed liquid crystal material which added cholesteric nonanoate severalpercent is used for the nematic liquid crystal which has a positive dielectric constant anisotropy as liquid crystal 10 as chiral matter for regulating the orientation of torsion. deltan of a mixed liquid crystal material is 0.24, and cell ** of the liquid-crystal-display element 2 is set as 7.5 micrometers.

[0050] A two-dimensional phase contrast plate is used for the phase contrast plate 52 at polarizing plates 3a and 3b using 45% of simple substance permeability, and the thing of 99.9% of degree of polarization. A two-dimensional phase contrast plate consists of a polycarbonate, and a ********** value is 2000nm.

[0051] Next, the arrangement conditions of each part material which constitutes LCD 51 are explained. As shown in drawing 10 , as arrow head G shows, 35 degrees of the liquid crystal molecular orientation shafts of one orientation layer 9 lean to the clockwise rotation from 9:00 orientation. As arrow head H shows, 55 degrees of the liquid crystal molecular orientation shafts of the orientation layer 9 of another side lean to the clockwise rotation from 12:00 orientation. Therefore, angle of torsion of a liquid crystal molecule is set as 250 degrees.

[0052] As arrow head I shows, 5 degrees of the absorption shaft orientations of polarizing plate 3a lean to the clockwise rotation from 6:00 orientation. As arrow head J shows, 70 degrees of the absorption shaft orientations of polarizing plate 3b lean to the clockwise rotation from 12:00 orientation. As arrow head K shows, the 30 degrees of the orientation of a lagging axis of the phase contrast plate 52 lean to the clockwise rotation from 6:00 orientation.

[0053] Here, the angle-of-visibility property of LCD 1 concerning this invention explained with the gestalt of operation is compared with the angle-of-visibility property of conventional LCD 51 explained in the example of a comparison using the drawing 11 and the drawing 12 . Explanatory drawing and the drawing 12 showing color difference change of the 6:00 to 12:00 orientation of the LCD except the optical diffusion plate 5 from LCD 51 of the former [drawing / 11], LCD 1 of this invention, and LCD 1 of this invention are explanatory drawing showing color difference change of the 3:00 to 9:00 orientation of the LCD except the optical diffusion plate 5 from conventional LCD 51, LCD 1 of this invention, and LCD 1 of this invention. in addition, the drawing 11 and the drawing 12 -- setting -- it is -- and nothing -- carrying out -- the existence of the optical diffusion plate 5 is shown

[0054] Although there is no difference about the LCD except LCD 1 of this invention and LCD 1 of this invention to the optical diffusion plate 5 with a big color difference change of 6:00 -12:00 orientation and the good property is both shown as shown in drawing 11 , about conventional LCD 51, color difference change is large extremely.

[0055] For example, when the following formula shows, the case where it is presupposed that elevation angle change of a foreground color arises is explained.

[0056]

[Equation 2]

$$\Delta E^{*}ab = 6$$

[0057] In 6:00 -12:00 orientation, the domain which elevation angle change of a foreground color does not produce becomes about 80 degrees about the LCD excluding [conventional LCD 51] LCD 1 of about 10 degrees and this invention, and LCD 1 of this invention to the optical diffusion plate 5.

[0058] Moreover, as shown in drawing 12 , although color difference change of 3:00 -9:00 orientation shows the good angle-of-visibility property about LCD 1 of this invention, about the LCD except conventional LCD 51 and LCD 1 of this invention to the optical diffusion plate 5, color difference change is large.

[0059] For example, when the following formula shows, the case where it is presupposed that elevation angle change of a foreground color arises is explained.

[0060]

[Equation 3]

$$\Delta E^{*}ab = 6$$

[0061] In 3:00 -9:00 orientation, the LCD excluding [LCD 51 of the former / domain / which elevation angle change of a foreground color does not produce] / the optical diffusion plate 5 becomes 80 degrees or more from LCD 1 of about 9 degrees and this invention about LCD 1 of about 55 degrees and this invention.

[0062] Thus, according to LCD 1 of this invention, the domain which elevation angle change of a foreground color does not produce can make 6:00 to 12:00 orientation, and 3:00 -9:00 orientation about 8 times to conventional LCD 51.

[0063] Here, the angle-of-visibility property of conventional LCD 51 explained in the example of a comparison is compared with the angle-of-visibility property of the LCD which formed the optical diffusion plate 5 in conventional LCD 51 using the drawing 13 and the drawing 14 . Explanatory drawing and the drawing 14 showing color difference change of the 6:00 to 12:00

orientation of the LCD which formed the optical diffusion plate 5 in LCD 51 and conventional LCD 51 of the former [drawing / 13] are explanatory drawing showing color difference change of the 3:00 to 9:00 orientation of the LCD which formed the optical diffusion plate 5 in conventional LCD 51 and conventional conventional LCD 51. in addition, the drawing 13 and the drawing 14 -- setting -- it is -- the existence of the optical diffusion plate 5 is shown

[0064] As shown in drawing 13 , there is no big difference at the LCD by which color difference change of 6:00 -12:00 orientation formed the optical diffusion plate 5 in conventional LCD 51 and conventional LCD 51, and both color difference change is large.

[0065] Moreover, as shown in drawing 14 , the angle-of-visibility property is improved about the LCD by which it formed the optical diffusion plate 5 in conventional LCD 51 about LCD 51 of the former [change / color difference / of 3:00 -9:00 orientation] although color difference change was large. Although it is ineffective to a remarkable thing from the hit where an elevation angle exceeds **20 degrees especially and elevation angle change of a foreground color has produced this, it is shown that the degree is improved greatly.

[0066] Thus, the domain which elevation angle change of a foreground color does not produce becomes large to conventional LCD 51, and even if elevation angle change of a foreground color arises, the degree is greatly improvable according to the LCD which formed optical diffusion plate 5 in conventional LCD 51, i.e., the LCD concerning this invention.

[0067] As mentioned above, although an angle-of-visibility property is improvable by forming the optical diffusion plate 5, a still good angle-of-visibility property can be acquired by combining with a 3-dimensional phase contrast plate.

[0068]

[Effect of the Invention] Like the above explanation, without reducing transverse-plane brightness in the specific orientation by having the optical diffusion plate which diffuses light, between the polarizing plate by the side of an observer, and a liquid-crystal-display element, elevation angle change of a foreground color can be improved and, according to the reflected type LCD of this invention, an angle-of-visibility property can be raised.

[0069] Moreover, between the polarizing plate by the side of an observer, and a liquid-crystal-display element, by having the phase contrast plate which improves the angle-of-visibility property of the orientation not to diffuse, elevation angle change of a foreground color can be improved with a sufficient balance in all orientation, and an angle-of-visibility property can be raised with an optical diffusion plate.

[0070] An optical diffusion plate carries out the laminating of the film of two sheets which has the field in which a refractive index is mutually different, and is constituted. furthermore, the aforementioned field It is prepared in parallel with the orientation in which only the predetermined angle inclined in the specific orientation to the orientation of a normal of a film. the aforementioned angle of each film While transverse-plane brightness is secured by being set up so that it may become the opposite orientation mutually considering the orientation of a normal as a center, elevation angle change of a foreground color can be improved and an angle-of-visibility property can be raised.

[0071] Furthermore, as for a phase contrast plate, by [55 degrees or more] being 75 degrees or less, the angle of the diffusion orientation of light and the lagging axis of a phase contrast plate which the refractive indexes nx, ny, and nz of the orientation of 3 dimension have the relation of nx>nz>ny, and diffused with the optical diffusion plate to make can improve elevation angle change of a foreground color with a sufficient balance in all orientation, and can raise an angle-of-visibility property.

[0072] Furthermore, when wavelength lambda is 633nm, by [or more 0.2] being 0.4 or less, the coefficient Nz which shows the rate of the ********** value change to elevation angle change of a phase contrast plate expressed with Nz=(nx-nz)/(nx-ny) can improve elevation angle change of a foreground color with a sufficient balance in all orientation, and can raise an angle-of-visibility property.

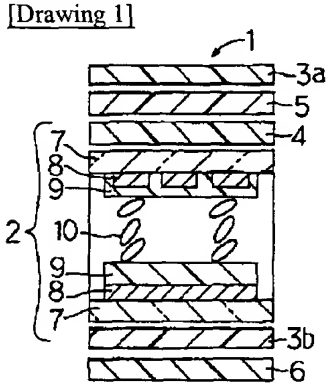
[Translation done.]

* NOTICES *

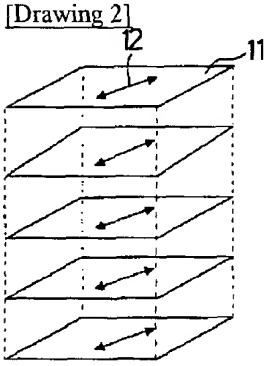
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

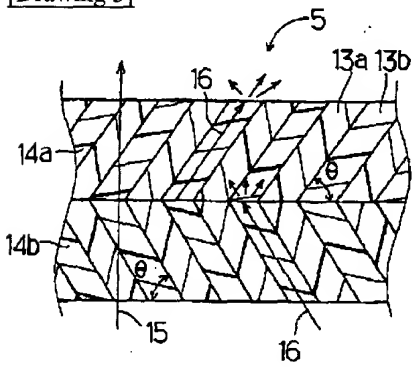
[Drawing 1]



[Drawing 2]



[Drawing 3]



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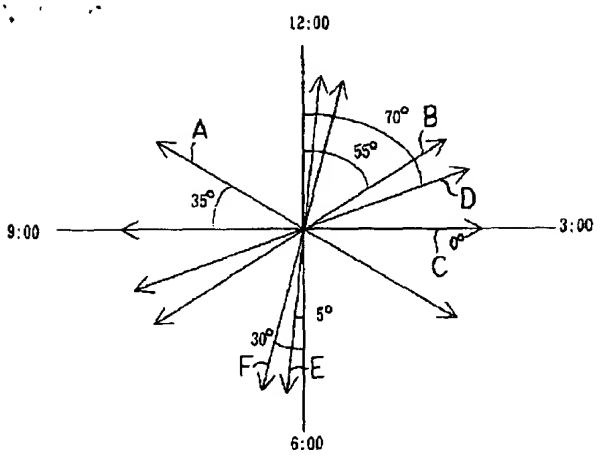

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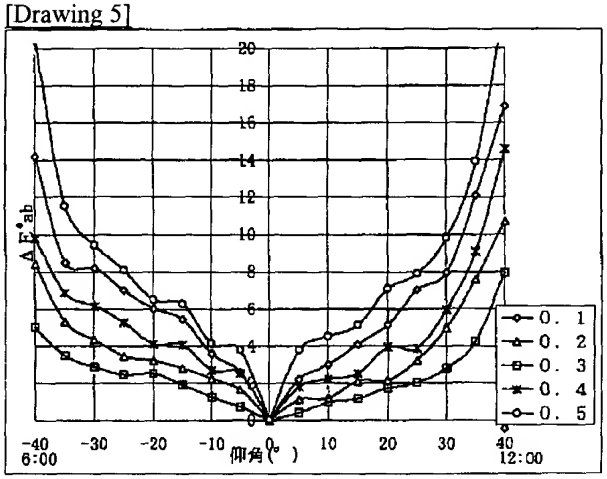

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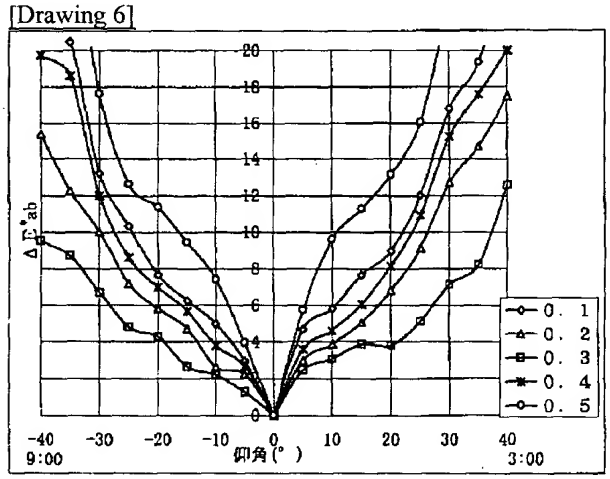

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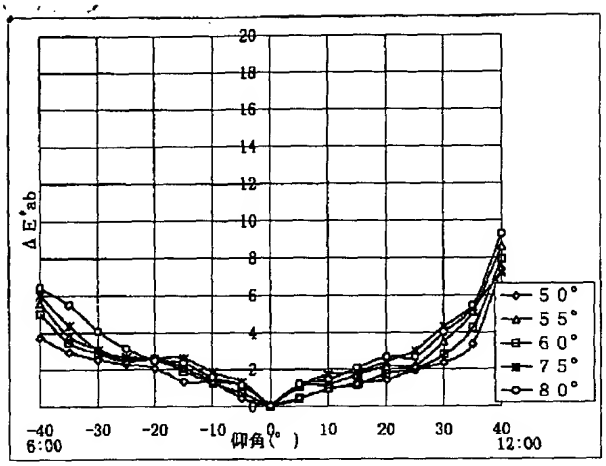
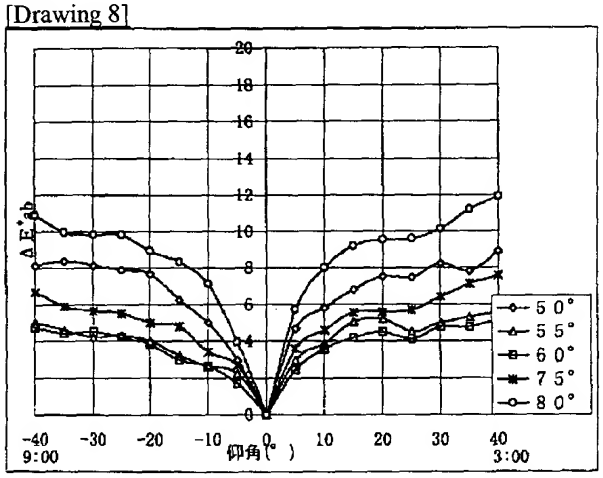


[Drawing 8]



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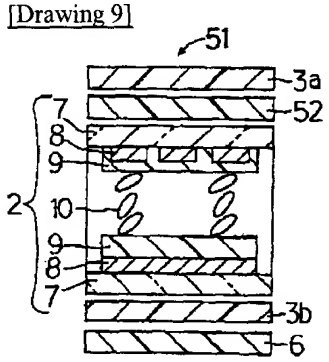
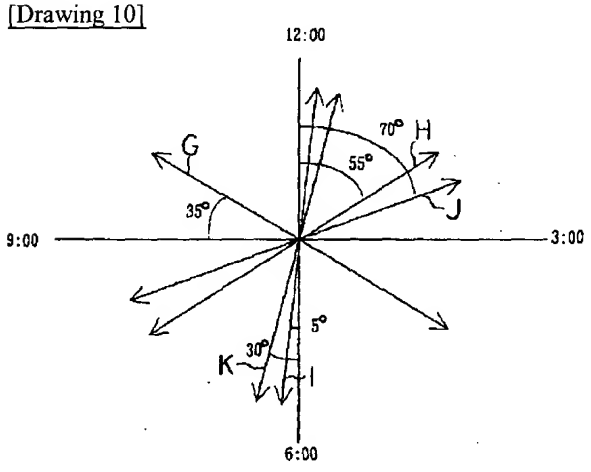
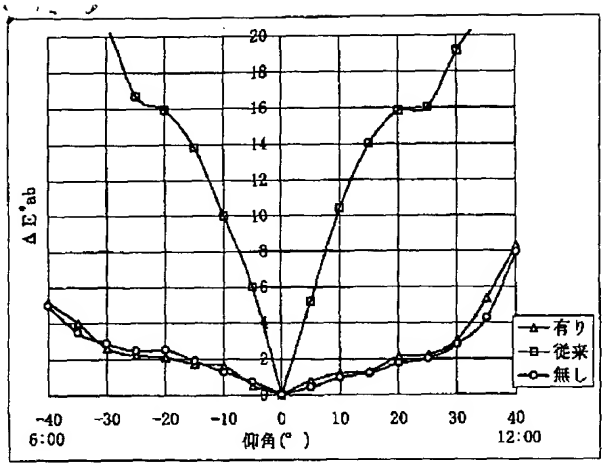


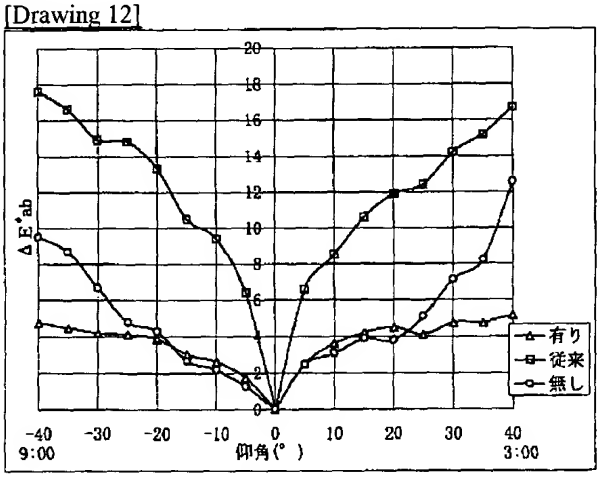
[Drawing 10]



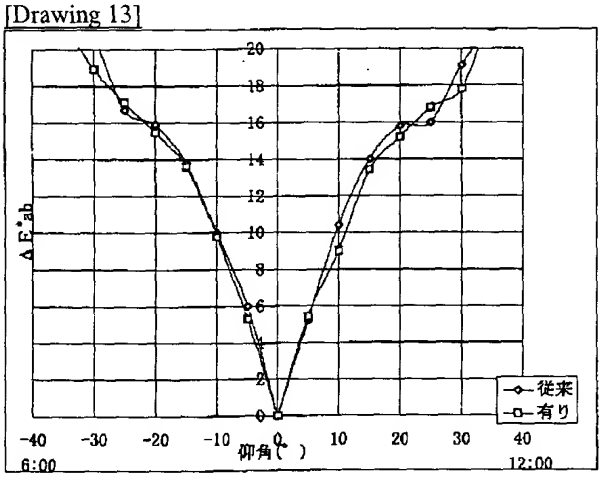
[Drawing 11]



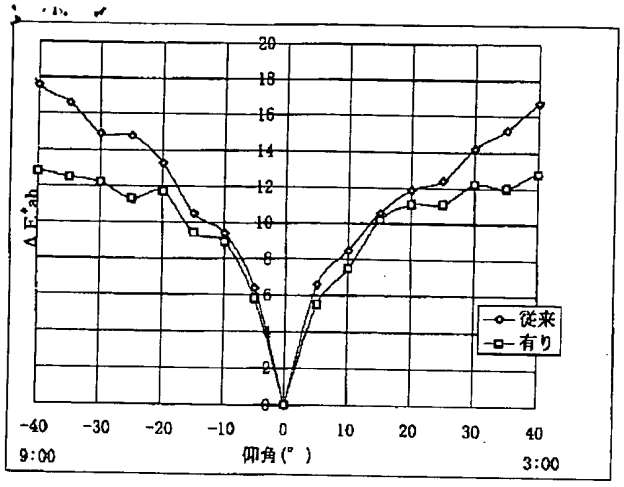
[Drawing 12]



[Drawing 13]



[Drawing 14]



[Translation done.]